RESPONSE OF VERTEBRATE FAUNA FORESTFIRE AND CLEARCUTTING IN SOUTH CENTRAL WYOMING

The Final Report

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Between

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and

The University of Wyoming

by

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ABSTRACT

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An investigation in the Medicine Bow and Sierra Madre Mountains of south-central Wyoming compared selected burns and clearcuts of the same age, with each other and with forested controls and with natural openings. The objectives were to determine differences in the effects of logging and fire on populations of mule deer (Odocoileus hemionus), elk (Cervus canadensis), small mammals, and birds. The reasons for the differences were determined and recommendations were made which would make clearcutting more closely simulate a forest fire.

Small mammal populations were sampled by capture, mark, and recapture techniques. Mule deer and elk were sampled with fecal-group counts and time-lapse photography. Time-lapse photography proved to be unsuitable due to differences in visibility caused by standing dead timber in the burned plots. Avifauna were sampled with a transect method. Linear regression was used to correlate use of plots by the animal species studied with various quantitative attributes of the vegetation present in the study plots.

Clearcuts supported more small mammals than burns. Clethrionomys gapperi was most numerous in forested control plots. Spermophilus lateralis and Eutamias minimus were most abundant in clearcut plots. Peromyscus maniculatus was more abundant in burned and clearcut plots than in forested control plots. Numbers of total small mammals, and S. lateralis were correlated with the amount of cover present. E. minimus appeared to use logging residue for escape cover. It was

recommended some logging residue be left to supply escape cover for small mammals.

Fecal-group counts indicated 49% of deer use was in burned areas and 26% in clearcut plots. The remainder was in natural openings and forested plots. Burned plots had 51% of the elk pellet groups, while clearcuts had 13%. The remaining 36% was in natural openings and forested plots. Deer and elk preferred areas with standing dead timber which acted as escape cover. Regression analysis indicated deer and elk select areas with a large number of forage species. Nutritional quality of mule deer and elk forage in the study areas was probably adequate, although the exact nutritional requirements of these species are not known.

In all plots the majority of bird consuming biomass was in the form of secondary consumers which were ground feeders and branch nesters. Bird species richness was related to plant species richness and the amount of standing dead timber present. Standing dead timber is necessary to supply nesting habitat and is possibly a limiting factor when scarce.

A wide variety of plant species present in burned plots provided food for a wide variety of insect species, which in turn provided food for a wide variety of bird species. Both fire and clearcutting provide ample foraging opportunities for ground feeding birds. It would be beneficial from an ecological viewpoint to optimize the number of bird species present. It was recommended some timber be left standing after logging and post-logging treatments which maximize the amount of forage entering an area be used. This would benefit mule deer, elk, and birds.

ACKNOWLEDGMENTS

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INTRODUCTION

Recently the U.S. Forest Service (USFS) has been criticized for allowing clearcutting on public lands. Criticism has come from factions of the Sierra Club, other environmental groups, and some professional foresters (Wood 1971; Bolle et al. 1970). The environmentalists believe clearcutting adversely affects both wildlife and the aesthetic appeal of the forest. Some foresters feel that clearcutting too often ignores multiple use planning and takes into account only timber harvesting (Bolle et al. 1970). Although clearcutting has been justified with the idea that it simulates forest fires (Wellner 1971), this has not been clearly shown.

It is certain that clearcutting, like fire, helps to maintain diversity by insuring that some forest areas are always in early seral stages; however, argument persists over whether succession is the same after clearcutting or forest fire, and whether both processes actually affect the ecosystem in the same manner. In the central Rocky Mountains, neither the relationship between birds nor small mammals and clearcutting has been studied. No one has compared fire and clearcutting anywhere.

Consequently, an investigation was initiated in 1973 to compare selected clearcut, burned, and untreated control areas, identifying and evaluating differences in:

1. Density, size, and species composition of tree type vegetation,
2. Density and species composition of herbaceous vegetation,
3. Populations and distributions of small mammals, birds, mule

deer, and elk,

4. Nutrient value of mule deer and elk forage.

Objective 4 was added in 1974 to test a hypothesis that differences in mule deer and elk utilization of the study plots could be resultant from differences in forage nutrient quality.

LITERATURE REVIEW

Very few studies have evaluated the effects of fire on small mammal populations in the Rocky Mountains. Those studies which have been performed, generally indicate more small mammals present in burned areas than in adjacent forested areas. After fire in Yellowstone National Park, lodgepole pine (Pinus contorta) forests, small mammal diversity increased for 25 years, then decreased. Deer mice (Peromyscus maniculatus) and chipmunks (Eutamias spp.) were the most abundant small mammals in the younger burned areas. Total small mammal density fluctuated with age, but was highest in the oldest burn, which is over 300 years old (Taylor 1969). Three years after fire in a northern Idaho fir (Abies spp.) forest, deer mouse and heather vole (Phenacomys intermedius) populations were higher on the burn than in an adjacent unburned forest (Stout et al. 1971). In northern Colorado, there were more animals and more species present eight years after a fire in a lodgepole pine forest, than on an unburned control plot. Deer mice, golden-mantled ground squirrels (Spermophilus lateralis), and heather voles were more abundant on the burned plot, while red-backed voles (Clethrionomys gapperi) were more abundant in the forested plot (Roppe 1974).

Most work concerning the effects of clearcutting on small mammals has been performed in the Pacific Northwest. California red-backed vole (C. occidentalis) and deer mouse abundance increased immediately after Douglas-fir (Pseudotsuga menziesii) was logged in Oregon. The slash (logging residue) was burned two months later. After the burning,

California red-backed voles disappeared and deer mice continued to increase (Gashwiler 1959). Ten years later, deer mice and Oregon voles (Microtus oregoni) were more abundant on the logged area than on the control. Chipmunks were more abundant on the clearcut for seven years after logging, then became more abundant in the forest. California red-backed voles continued to be more abundant on the unlogged plot (Gashwiler 1970). Deer mice and chipmunks have also been shown to increase after Douglas-fir was logged in northern California (Tevis 1956).

Fire and clearcutting can affect cervid use of an area in three ways. First, they create openings for feeding; second, they can affect forage production; and third, they can affect forage nutritional quality. Fire creates openings used by deer (Odocoileus spp.) and moose (Alces alces) in northern Canada, but these openings are possibly detrimental to barren ground caribou (Rangifer tarandus) (Lloyd 1938). However, there is some disagreement over this last point (Johnson and Rowe 1975). Both moose and white-tailed deer (O. virginianus) use burned areas in northern Minnesota, although the large burns (5,000 ha in this case) and early successional stages favor moose more than deer (Irwin 1975). Elk (Cervus canadensis) and mule deer (O. hemionus) used a burned area in a Colorado lodgepole pine forest more than the adjacent forest during the fall, winter, and spring, but summer use of the two areas was not significantly different (Roppe 1974). Burning small patches of California chamise (Adenostema fasciulata) brushlands improves deer habitat (Biswell et al. 1952). Deer in Arizona pinyon (Pinus edulis)-juniper (Juniperus osteosperma) woodland used burned areas more than unburned forest (McCulloch 1969). Prescribed ground fires in the southern United

States are believed to improve white-tailed deer habitat (Shrauder and Miller 1969).

Openings created by clearcutting are also used by deer and elk. In an Arizona spruce (Picea engelmannii)-fir (Abies lasiocarpa) forest, deer and elk preferred clearcuts to natural openings (Reynolds 1966). Clearcuts are preferred summer deer habitat in southeastern Wyoming lodgepole pine forests (Strickland 1975). In Arizona ponderosa pine (Pinus ponderosa) forests, deer and elk use increased during the first four years after logging (Patton 1969). Ten years after Colorado spruce (P. engelmannii)-fir (A. lasiocarpa) forests were clearcut, mule deer use was greater in logged areas than in an adjacent unlogged area (Wallmo 1969). The cutover area supported almost twice as many deer as the adjacent virgin forest (Wallmo et al. 1972). In this same area, mule deer use was greater in uncut areas for the first two years after logging, possibly due to dense slash which subsequently settled (Wallmo 1969).

Openings created by either fire or clearcutting are used by deer and elk. The reasons usually cited for this use are increased forage availability and increased forage quality (Klein 1970). Studies performed in Idaho have shown that forage production increases after burning (Leege 1969; Lyon 1971). A study performed in Yellowstone National Park indicated preferred forage species to be most abundant in burns less than 25 years of age (Taylor 1969). An abundance of forage in a Colorado burn was probably the reason for increased deer and elk use of the area (Roppe 1974). Annual burning of central Missouri prairie increased production of forage (Kucera and Ehrenreich 1962). Production of all types of forage increased after a wild fire in an Arizona ponderosa

pine forest (Kruse 1972).

Clearcutting is also thought to improve forage production. Clearcuts in an Arizona spruce-fir forest had more forbs than did natural openings (Reynolds 1966). Forbs are preferred summer food for mule deer and elk (Strickland 1975; Mackie 1970; Martinka 1968; Compton 1974). Browse production in Arizona ponderosa pine forests was higher on logged areas than on unlogged areas for 11 years after logging (Reynolds 1962a). In Idaho coniferous forests, production of preferred browse species was greater on clearcut areas than in mature forest (Nyquist 1973). In Colorado spruce-fir forests, cutover areas had more forage and more forage species 15 years after logging (Wallmo et al. 1972).

The effects of fire on forage nutrient quality are well established. Fire releases nutrients to the soil causing burned areas to have higher forage protein content than unburned areas (Einarson 1946; DeWitt and Derby 1955; Leege 1969). It has been shown that deer select forage of high protein content over forage of low protein content (Einarson 1946; Nagy et al. 1969). Fire releases many minerals to the soil that help to fertilize it (Ahlgren and Ahlgren 1960). Among these are sodium (Lewis 1974), nitrogen, phosphorus, and potassium (Wagle and Kitchin 1972), and calcium (Ahlgren 1960). If there are more minerals in the soil then there are more available to plants, and it is possible that forage nutritional quality will be greater.

Clearcutting is also thought to increase forage quality (Klein 1970; Lay 1956; Robinson 1958), but no data have been presented. Soil minerals have been shown to increase after clearcutting (Cole and Gessel 1965).

The above discussion assumes food to be limiting for deer and elk.

This has been questioned by Pengelly (1972), who believes that cover and human encroachment may be just as important as food in determining wildlife use of an area.

Bird diversity has been found to increase after wildfire in various habitats throughout the Rocky Mountains, such as Yellowstone National Park (Taylor 1969), Colorado (Roppe 1974), and Mexico (Marshall 1963). On the eastern slope of California's Sierra Nevada, there was little difference in species composition and total density between burned and unburned plots (Bock and Lynch 1970). However, Dark-eyed Juncos (Junco hyemalis), American Robins (Turdus migratorius), and Fox Sparrows (Passerella iliaca) were more abundant on the burned plot than on the unburned plot. Clearcuts have been shown to provide habitat for Dark-eyed Juncos (Hagar 1960), Blue Grouse (Dendragapus obscurus) (Zwickell and Bendell 1972), Mountain Bluebirds (Sialia carrucoides), Eastern Bluebirds (S. sialis) (Conner 1974), and woodpeckers (Conner and Crawford 1974).

The size and shape of forest openings is often purported to be a factor influencing wildlife use of an area (Bendell 1974; Miller and Watson 1973). However, results of studies performed in different habitats conflict. In Arizona ponderosa pine forests, 18-ha has been recommended as the maximum size (Patton 1974), while openings less than 8-ha have been recommended for Arizona spruce-fir forests (Reynolds 1966). However, preliminary studies performed in Montana indicate 24-ha is optimum for deer, while elk will use openings up to 40-ha in size (Lyon 1975). A different Montana study showed 6 to 10-ha to be optimum for elk (Kirsch 1962).

In actuality, the amount of edge present and other factors may be

of more importance than the actual size of the opening. The amount of edge influences the interspersion of cover types (Leopold 1948; McGinnis 1969; Patton 1975). This is important since most species require more than one type of cover in their habitats (Leopold 1948). Long narrow areas have more edge than square or circular areas of the same hectarage (Patton 1975). Several studies have indicated deer and elk use declines as distance from the edge increases (Patton 1974; Reynolds 1962b; McCulloch 1969). Results from Colorado indicate quantity and quality of forage may be more important than either size or shape for determining deer use of clearcut areas in lodgepole pine forests (Regelin et al. 1974). Cover could also be an important parameter as shown by preliminary results from Montana which indicate forage height may be important (Lyon 1975), and a study performed in Arizona pinyon-juniper woodland, which indicates standing dead timber and fallen trunks left after fire provide important cover for deer (McCulloch 1969). Findings in a Colorado lodgepole pine forest also indicate standing dead timber to be an important source of cover (Roppe 1974).

Little is known about the effects of size and shape on birds. Most game birds apparently prefer smaller openings than deer or elk, but here again the amount of edge and interspersion is very important (Bendell 1974; Miller and Watson 1973).

The literature cited here shows several trends to be present. Deer mice, chipmunks, and golden-mantled ground squirrels are more abundant in forest openings, such as burns or clearcuts, than in forested areas, while red-backed voles are more abundant in forested areas. Deer and elk use burned and clearcut areas throughout the Rocky Mountains. This

is due at least partially to increased forage availability. Fire, in addition to creating increased forage availability, also creates increased forage quality. Finally, bird diversity of an area increases after fire. One other factor is apparent: many investigators have studied fire and several have studied clearcutting, but no one has compared the two, in order to determine if some animals use burned areas more than clearcut areas or vice-versa.

STUDY AREAS

In an investigation of this nature, one immediate problem is finding suitable study areas. Clearcuts are abundant, but areas burned by wildfire are not. The wildfires that do occur are frequently extinguished before they become larger than 2-ha, and ones which are larger are frequently manipulated in some manner, after the fire is out. As a result, the number of suitable burned sites is very small. In this case there were two burned areas which met most of the criteria listed below. It would have been preferable to have a larger number of suitable areas to choose from, but two was considered an adequate number, since it would have been difficult for one individual to study more than two areas, each containing four plots.

The criteria used in selecting the study sites were as follows:

1. It was decided that study plots should have been burned or clearcut after 1959. There were two reasons for this. First, younger areas would not have young trees large enough to obstruct viewing with time-lapse cameras. Second, the author was already familiar with many areas that had been clearcut since that date.

2. Since size appears to affect use of openings, the burned and clearcut areas being compared should be approximately the same size.

3. It appears conceivable that use could switch from one type of area to another as the areas get older. Therefore, the burns and clearcuts must be the same age for the comparisons to be valid.

4. In order to be certain that use by the same big game herds is

being compared, the burns should be in the same general area as the clearcuts with which they are being compared.

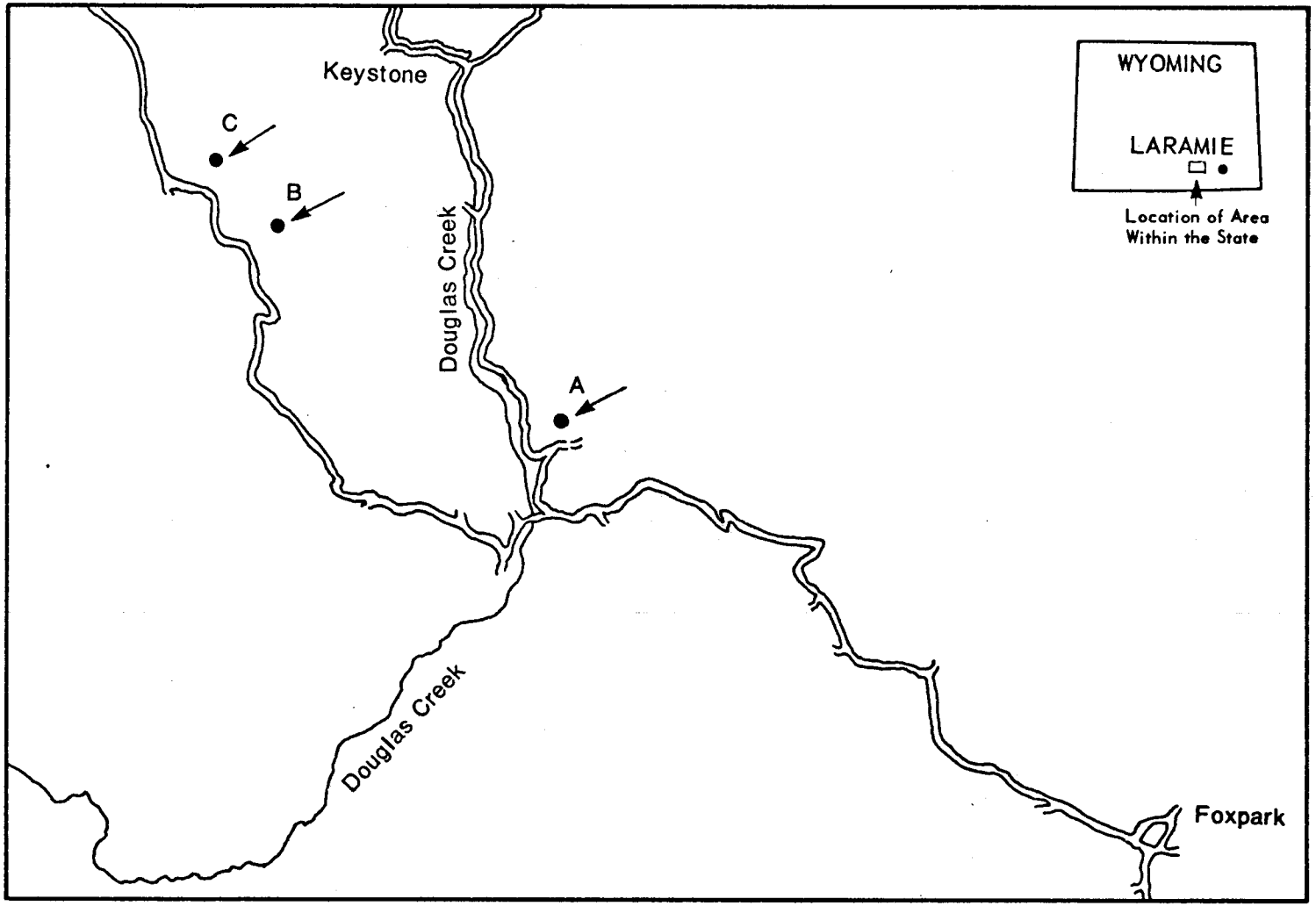
5. Since the main objective of the study was to compare a natural perturbation, wildfire, with a man-made perturbation, clearcutting, it was desirable to have burned areas which had not been manipulated by any type of planting or other treatment.

6. It was desirable to have more than one comparison of burned and clearcut areas, so results could be compared and trends sought.

7. Since the author also had teaching responsibilities starting in late August, and since field work would still be conducted in September, it was desirable to have the study areas within easy driving distance of Laramie.

Each study area contained four plots: a burn; a clearcut; an unlogged, unburned, forested control; and a natural opening or park. The Snowy Range study area was located on Douglas Creek (T14N R79W) 56 km west of Laramie, Wyoming, at an elevation of 2750-2900m (Fig. 1). The fire in this area occurred in 1964, starting in an area clearcut in 1961, and moving rapidly into a forested area where it crowned. The 83-ha burned plot (SW1/4, Sec. 35) was on a 12% west facing slope. When first observing the plot in early summer, one sees abundant standing dead timber, and some young lodgepole pine trees less than 1-m high. Grasses and forbs also appear to be abundant.

The 35-ha Snowy Range clearcut (SW1/2, Sec. 28) was on an 8% east-facing slope; slash had been lopped and scattered. When looking at this area, abundant young lodgepole pine trees and abundant dwarf huckelberry (Vaccinium scoparium) are obvious. There are also two small patches of


Keystone
C
B
A
Douglas Creek
Douglas Creek
Foxpark
WYOMING
LARAMIE
Location of Area
Within the State

subalpine fir (A. lasiocarpa).

The 10-ha Snowy Range forested plot (SW1/4, Sec. 28) was on an 8% east facing slope in a mature lodgepole pine forest. Dwarf huckelberry is abundant and there are very few young trees.

The 10-ha Snowy Range park (NE1/4, Sec. 29) is on level ground. Grasses are abundant, with patches of willow (Salix spp.) present. There are no trees in the plot.

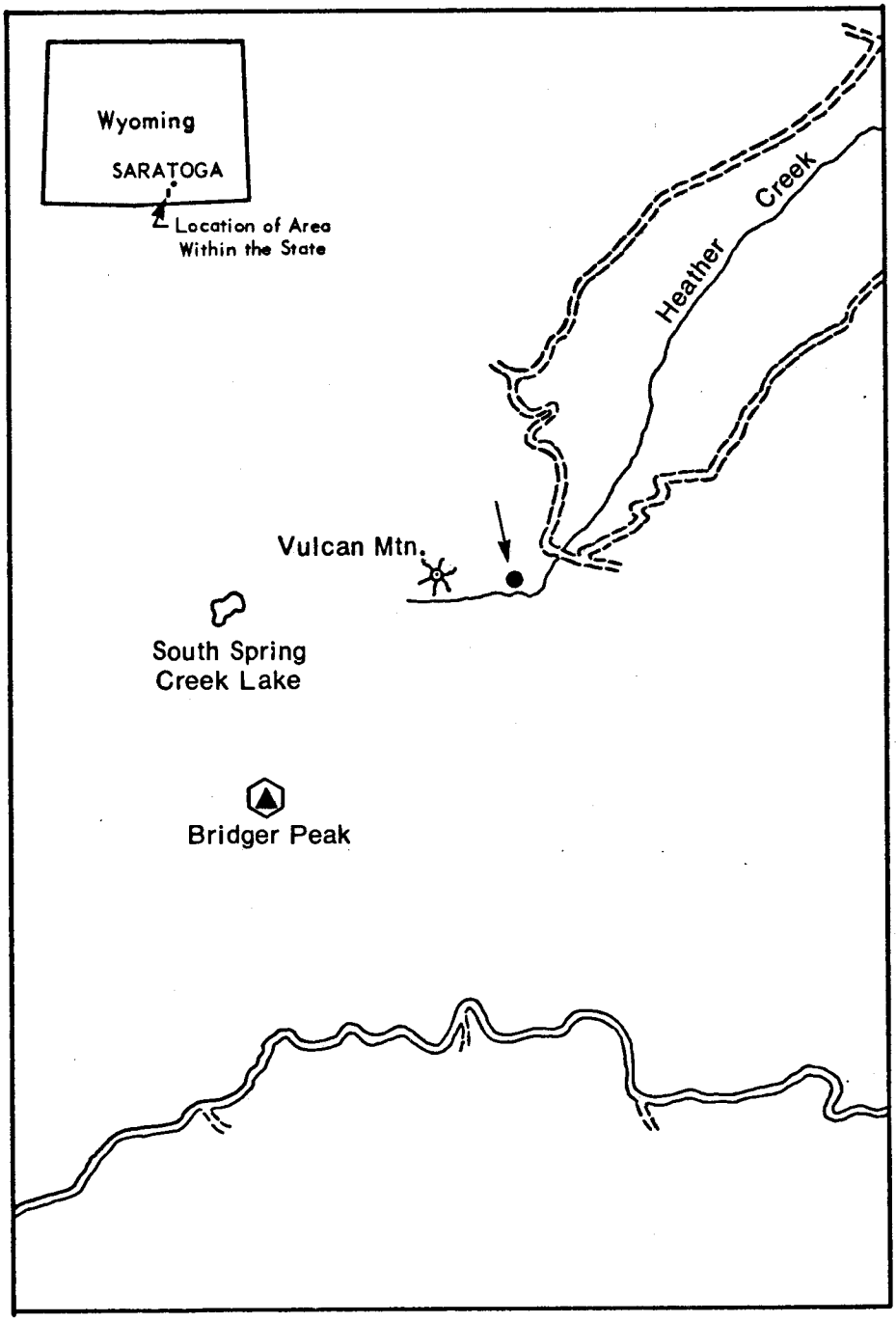
The Sierra Madre study area was on Heather Creek, approximately 30 km southwest of Saratoga, Wyoming, in the W1/2, Sec. 6 T14N R85W (Fig. 2). All the plots were on an east facing 26% slope at an elevation of 2865 to 2990m. In the long and narrow, 6-ha burned plot standing dead timber appears very dense, but there are some large patches in the plot where all of this timber has been blown down. Sedges and forbs appear to be abundant. The fire which took place in 1968, started in the adjacent clearcut plot and moved into the burned plot.

Forbs and sedges also appear to be abundant in the 44-ha Sierra Madre clearcut. There is a trace of young trees and no mature trees. There is also some standing dead timber present. Slash on this clearcut had been piled and burned.

The 10-ha Sierra Madre forested plot was located in a lodgepole pine-Engelmann spruce (P. engelmennii)-subalpine fir forest. Dwarf huckelberry is abundant, and there are abundant young trees creating an understory.

The 10-ha Sierra Madre park plot is an irregularly shaped area due to fingerlike projections of conifers into the area. Grasses and forbs appear to be abundant. There are no living or dead trees in the plot.

There are no comparative weather data for the two study areas.


Wyoming
SARATOGA
Location of Area
Within the State
Heather Creek
Vulcan Mtn.
South Spring
Creek Lake
Bridger Peak

However, there are data on water content of the snowpack, available from the United States Soil Conservation Service. These data are from locations near the study areas (Table 1). They indicate there is more moisture in the Sierra Madres than in the Snowy Range.

Table 1. Average water content (cm water) of the snowpack from 1958 to 1972, in areas near the study areas. Data are from the United States Soil Conservation Service.

Mountain Range Location, elevation	Water content of snowpack (cm) February	March	April	May
Snowy Range				
Sec. 17, T14N R78W 2866-m	24	35	38	33
Sec. 21, T13N R78W 2805-m	11	16	18	15
Sierra Madre				
Sec. 29, T14N R85W 2988-m	53	70	84	94
Sec. 13, T14N R85W 2500-m	21	29	34	21
Sec. 26, T14N R85W 2744-m	35	44	50	46

MATERIALS AND METHODS

A random numbers table was used to determine distance between 100 points in each burned, clearcut, and unburned, unlogged control plot. Each point was marked with a numbered surveyor's stake. The points were located away from the edge of the plots in order to avoid edge effect. In 1973, all 100 points in each plot were used for sampling herbaceous vegetation and for determining density of trees less than 2-cm diameter breast height (dbh). During the same year, 50 of the original 100 points in each plot were randomly chosen as centers of 40-m^2 circular plots (radius = 3.6-m) to ascertain deer and elk use by the fecal-group count technique (Robinette et al. 1958). Forty of the original 100 points in each forested control plot were used for determining the density of living trees larger than 2-cm dbh.

In 1974, 50 points were located in each park in a similar manner. These were used for fecal-group counts, as were the 50 points located in each burn and clearcut not used for this purpose in 1973. Also in 1974, 40 points in each burned, clearcut, forested, and park plot were used for sampling herbaceous vegetation.

Herbaceous vegetation was sampled by the canopy-coverage technique (Daubenmire 1959). A 20 x 50-cm rectangle was painted in a manner which indicates 5, 25, 50, 75, and 95% of its area. Each plant species inside the rectangle was then placed in one of six coverage classes: 0-5%, 5-25%, 25-50%, 50-75%, 75-95%, and 95-100%. When the sampling results were tabulated, class midpoints, rather than the actual percent cover

estimated to be present were used. This helped to eliminate observer bias. When averaged, the midpoint values are a good estimate of the actual cover present (Daubenmire 1959). This method provides both cover and frequency of occurrence. When analyzing the data frequency of occurrence was used since it appeared to be more consistent from one year to the next.

The amount of slash present was also determined with the canopy-coverage method. During 1973, all small sticks and pine cones were designated as slash. In 1974, slash was categorized into size groups in order to yield more information. In the latter classification, small sticks (less than 1.25-cm in diameter) and pine cones were designated as litter. This resulted in a discrepancy in the amount of slash present from one year to another in some of the study plots.

In each of the plots, density and frequency of occurrence of trees less than 2-cm dbh were determined from rectangular (2-m x 1/2-m) quadrats at each of the 100 points. Density of trees over 2-cm dbh in forested control plots was determined by use of the point-quarter distance method (Cottam and Curtis 1956). Living trees in burned, clearcut, and park plots were counted.

Density of dead timber in burned and clearcut plots was determined from USFS aerial photographs taken in 1973. Using a stereo viewer, a grid (64 squares/6.25-cm^2) covering the entire plot was placed over one black and white transparency of a stereo pair of aerial photographs (scale 1:5280). Each square on the grid was numbered, and the standing dead trees in 15 randomly selected squares, each representing 0.028-ha, were then counted.

Small mammals were live-trapped in large Sherman live-traps (7.5 x 8.75 x 22.5-cm), using a mixture of peanut butter, rolled oats, hamburger, Velveeta cheese, raisins, and bacon as bait. This bait mixture has been shown to be better than others for trapping a wide diversity of small mammals (Patric 1970). In the center of each clearcut, burned, and forested plot a permanent grid 32 x 224-m containing 45 trapping stations 16-m apart was established. All three plots in an area were trapped simultaneously for 135 trap nights each in July and 135 trap nights each in August of 1973, and 270 trap nights each in September 1974. Traps were checked each morning and evening during the trapping period. A snap-trap line 304-m long was used in late September 1973 in each of the plots in the Sierra Madre study area, and in early October in each of the three plots in the Snowy Range study area. Each line contained 20 stations set 16-m apart. Each station had two museum special mouse traps and one Victor rat trap. The lines were open for 72 hours and traps were checked each morning and evening.

The data collected were insufficient to calculate population densities, due to small sample size and insufficient data regarding home range size. The number of individuals trapped and trap success per trap night, including recaptures, were used as indices of small mammal abundance. The number of individuals trapped was treated statistically with Chi-square analysis (Neu, Byers and Peek 1974).

Relative big game use of the study plots was determined from fecal group counts (Robinette et al. 1958), and time-lapse photography. Fifty circular fecal-group plots (radius = 3.6-m) in each plot were used in each year as described above. Accumulated fecal-groups were counted in

October 1973, and September 1974. The parks were added to the study in 1974 as a more realistic control for the big game portion of the study, since they can be expected to be used for feeding just as the burned and clearcut plots are.

A super-8-mm time-lapse photography camera system (Diem et al. 1973) was used to detect big game use of portions of the study plots selected for maximum viewing area. On 19 August 1973, four cameras set at 12 frames/hr were placed in the study plots; one in each burn and clearcut. They were removed from the Sierra Madre plots on 20 October 1973, and from the Snowy Range plots on 23 October 1973. In 1974 the cameras in the Snowy Range were returned to the study plots on 30 May. Cameras in the Sierra Madres were put in place as soon as weather permitted access to the study plots, 13 June in the clearcut, and 25 June in the burn. The area viewed by the cameras was determined by having one person look through the view finder while another walked until out of sight. He then walked back into view and walked across the field of view until the edges were determined. The distances between the edges and from the edges to the camera were paced. All angles were recorded with a compass, and the area inside the traingular field of view was calculated. Since the data gathered with cameras violate assumptions of randomness, no attempt was made to analyze them statistically.

Forage in the burns, clearcuts, and parks was clipped at the midpoint of the stem in late June, mid-July, early August, mid-August, and early September 1974. A Parr oxygen bomb calorimeter (Model 1341) was used to measure total energy content of collected samples. Additionally, samples were analyzed for protein, lipid, crude fiber, sodium, potassium,

calcium, and phosphorus content by the Wyoming State Chemistry and Bacteriology Laboratory at the University of Wyoming, Laramie. Standard Association of Analytical Chemists procedures, as shown in Table 2, were used for these analyses.

Birds were censused by the strip transect survey method (Taylor 1969). Starting at a representative point the observer stands for five minutes recording all the birds seen and heard within 25-m and then slowly paces 100-m for the next 5 minutes, recording all the birds within 25-m. The process is then repeated for the length of the transect, which in this study varied with size of the plot (Table 3). In this study, each bird was recorded and counted as a single individual. In all plots except the Sierra Madre burn, the centrally located transect was U-shaped. The distance between the two arms was 100-m in 1973, and 200-m in 1974, except in the Snowy Range control, where it was 100-m both years. The Sierra Madre burn transect was a straight line, due to the long narrow shape of the plot. The transects were relocated in 1974 in an attempt to make them longer. This was not successful in the Sierra Madre burn, which is long and narrow. Instead, attempts to reduce edge effect shortened the transect (Table 3).

Plots were censused one evening and one morning in August 1973, except for the Sierra Madre control, where rain interfered with the evening census. In 1974, each plot was censused one evening and one morning in late June, and one evening and morning in early July, except for the Snowy Range control where rain made the July evening count impractical. Morning censuses started just after sunrise, and evening censuses were timed to end just before sunset.

Table 2. Standard Association of Analytical Chemists procedures used for forage nutrient analysis.

Nutrient	Procedure
Protein	Kjeldahl method
Lipid	Ether extraction
Fiber	Sulfuric acid base digestion process
Calcium	Atomic absorbtion spectroscopy
Phosphorus	Phosphomolybdic acid precipitation
Sodium	Flame photometric spectroscopy
Potassium	Flame photometric spectroscopy

Table 3. Length of bird censusing transects.

Plot	Transect length 1973	1974
Snowy Range		
Burn	700 m	800 m
Clearcut	700 m	800 m
Control	500 m	500 m
Sierra Madre		
Burn	500 m	400 m
Clearcut	700 m	800 m
Control	500 m	500 m

The number of birds observed was converted to standing crop biomass using mean weights available from the literature (Bock and Lynch 1970; Murray and Jehl 1964; Poole 1938; Salt 1957). Biomass was converted to consuming biomass by the equation $(\text{Mean weight})^{0.7}$ (Salt 1957). Willson (1974) has described food niches of Illinois birds by placing them in guilds. Her system has been followed here with two exceptions (Table 4). Ground and brush feeders were grouped together in a manner similar to Bock and Lynch (1970), and a category describing nesting site was included to give a four digit number, rather than a three digit number.

Simple linear regression (calculated with a program stored in a Monroe Model 1860 desk top calculator) was used to investigate possible relationships between frequency of various vegetation types and small mammal, deer, elk, and bird data. The data for each study area were regressed for each year using the vegetation data as the independent variable. This yields four regression lines for each possible relationship. If there is no relationship, the probability of any one of these relationships having a positive slope is 0.5. The probability of all four having a positive slope is $(0.5)^4$ or 6.25%. Thus, if all four regressions have the same slope the odds against this happening by chance are 93.75%. This is the confidence level used when discussing the results of the regression analysis.

Table 4. Description of guilds, each species is given a four digit number based on the system described here. For instance, Cassin's finch is in guild 1234 indicating that it is a herbivorous ground gleaning branch nester.

	A. Primary food source	B. Foraging station	C. Foraging behavior	D. Nesting site
1.	Herbivore	Bark	Bark drilling	Cavity
2.	Insectivore	Ground-brush	Bark gleaning	Ground
3.	Omnivore	Low-canopy	Ground gleaning	Bush
4.		Mid-canopy	Foliage gleaning	Branch
5.		High-canopy	Sally	

RESULTS AND DISCUSSION

Small Mammals

The number of individual small mammals trapped, and the results of Chi-square analysis of this data are shown in Table 5. The statistical analysis shows no clear trends between burned and clearcut plots relative to total small mammals or any individual small mammal species. Population levels were higher in 1974 than in 1973 (Table 6). Since the 1974 sample size is larger, a better indication of differences actually present might be given by the 1974 data.

Red-backed voles (Clethrionomys gapperi)

In 1974, the control plots had significantly more red-backed voles than either the burned or clearcut plots (Table 5). These results are consistent with several other studies which have shown red-backed voles to occur in forested areas rather than openings in California (Tevis 1956a), Oregon (Gashwiler 1970), Colorado (Williams 1955), Minnesota (Krefting and Ahlgren 1974), and Wyoming (Brown 1967). It can be concluded, red-backed voles are a forest species.

Least chipmunks (Eutamias minimus)

Least chipmunk numbers were significantly higher in the clearcut plots than in the burned or control plots during 1974 (Table 5). Results of this study and others from forested areas in Wyoming (Taylor 1969; Skryja 1970) indicate chipmunks prefer openings to forested areas. Regression analysis indicates a negative relationship between least

Table 5. Number of individual small mammals trapped by species. Significant differences were determined by use of Chi-square analysis (Neu, Byers, and Peek 1974).

Year / Species	Snowy Range			Sierra Madre		
	Burn	Clearcut	Control	Burn	Clearcut	Control
1973						
Clethrionomys gapperi	0	0	0	0	0	4
Eutamias minimus	3	7	2	3	7	10
Microtus montanus	0	1	0	0	0	0
Peromyscus maniculatus	9[c]	0	1	5[a]	12[d]	2
Phenacomys intermedius	1	0	0	6	0	0
Sorex sp.	0	0	0	1	0	2
Spermophilus lateralis	4	9[d]	0	8[a,b]	22	3
Total	17[a,c]	19[d]	3	23[a,b]	41[d]	21
1974						
Clethrionomys gapperi	1[c]	1[d]	18	0[b]	0[d]	11
Eutamias minimus	0[a,b]	22[d]	0	14[c]	18[d]	3
Microtus montanus	0	1	0	0	0	0
Neotoma cinerea	1	0	0	0	0	0
Peromyscus maniculatus	9[b,c]	2	0	7	14	6
Phenacomys intermedius	0	0	0	3[a,b]	13[d]	1
Sorex sp.	0[c]	0[d]	14	5	4	0
Spermophilus lateralis	0[a,b]	12[d]	1	8	8	2
Total	11[a,b,c]	38	33	37[a,b]	57[d]	23

[a]Significant difference between all three plots in an area (P = .05).

[b]Significant difference between the burned and clearcut plots in an area (P = .05).

[c]Significant difference between the burned and control plots in an area (P = .05).

[d]Significant difference between the clearcut and control plots in an area (P = .05).

Table 6. Trap success (Animals trapped/1000 trap nights). These figures include recaptures.

Year / Species	Snowy Range			Sierra Madre		
	Burn	Clearcut	Control	Burn	Clearcut	Control
1973						
Clethrionomys gapperi	0	0	0	0	0	10
Eutamias minimus	7	20	4	7	17	25
Microtus montanus	0	2	0	0	0	0
Peromyscus maniculatus	20	0	2	12	30	5
Phenacomys intermedius	2	0	0	15	0	0
Sorex sp.	0	0	0	2	0	5
Spermophilus lateralis	9	20	0	22	54	7
Total	38	42	7	59	101	52
1974						
Clethrionomys gapperi	4	18	96	0	0	92
Eutamias minimus	0	148	0	133	181	148
Microtus montanus	0	4	0	0	0	0
Neotoma cinerea	4	0	0	0	0	0
Peromyscus maniculatus	44	15	0	74	144	63
Phenacomys intermedius	0	0	0	18	67	4
Sorex sp.	0	0	55	11	15	0
Spermophilus lateralis	0	140	4	33	74	7
Total	74	326	156	270	481	181

chipmunks and the frequency of all vegetation (Table 7). Results from Wyoming's Great Divide Basin, where least chipmunks were more abundant in areas with over 40% canopy cover as opposed to areas with less than 40% canopy cover (Maxell 1973) are in opposition to the results of this investigation. The negative relationship between least chipmunk abundance and plant frequency is difficult to explain. It is possible the least chipmunks are responding to a factor or factors not considered in this study. If this is true, the vegetation could also be responding to the same factor, and the relationship seen here is a manifestation of both chipmunks and vegetation responding to the same factor. Most of the least chipmunks were trapped in areas with abundant slash or down timber, but the regression analysis shows no relationship between chipmunks and slash. Nevertheless, observations indicate this is probably part of their habitat, serving as escape cover. It should also be mentioned that slash or down timber makes least chipmunks more visible, since they prefer to perch on and run along the tops of logs. This has aesthetic value since many people enjoy seeing chipmunks.

Golden-mantled ground squirrels (Spermophilus lateralis)

Golden-mantled ground squirrels were more abundant in burned and clearcut plots than in control plots (Table 5). No recognizable trend between burned plots and clearcut plots was observed. Golden-mantled ground squirrels have been shown to invade clearcut areas in the Sierra Nevada Mountains (Tevis 1956b), and burned areas in Colorado (Roppe 1974). However, they were not abundant in burned areas in Yellowstone National Park (Taylor 1969).

Regression analysis indicates a negative relationship between frequency of total vegetation (Table 7), and numbers of golden-mantled

Table 7. Frequency of major species, plant types, total vegetation, and slash occurring in the study plots.

Year		Snowy Range				Sierra Madre			
	Vegetative attribute	Burn	Clearcut	Control	Park	Burn	Clearcut	Control	Park
1973									
	Total vegetation	98	86	93		99	86	94	
	Vaccinium scoparium	6	76	93		70	41	89	
	Carex brevipes	33	11	0		44	47	28	
	Arnica cordifolia	3	12	8		47	40	39	
	Epilobium angustifolium	5	50	6		40	57	8	
	Forbs	87	58	13		86	80	57	
	Grasses and sedges	67	15	3		59	49	31	
	Shrubs	15	80	93		72	47	90	
	Slash	29	88	38		50	40	22	
	Number of species	26	17	9		18	16	12	
1974									
	Total vegetation	99	90	100	100	100	95	98	100
	Vaccinium scoparium	0	77	100	0	82	55	95	62
	Carex brevipes	49	13	5	0	50	50	20	30
	Arnica cordifolia	5	12	15	0	65	50	52	30
	Epilobium angustifolium	2	52	2	0	50	68	5	10
	Forbs	78	58	15	55	95	85	60	92
	Grasses and sedges	77	20	5	90	52	60	28	30
	Shrubs	11	83	100	10	88	60	28	30
	Slash	42	68	32	--	45	30	15	--
	Number of species	21	12	5	10	16	16	12	22

ground squirrels (Table 5). As with least chipmunks, this negative relationship could reflect a res, nse of both the squirrels and the vegetation to a factor not measured in this study. Golden-mantled ground squirrels showed positive relationships with the frequency of fireweed (Epilobium angustifolium), the frequency of forbs, and the frequency of slash (Table 7). Like the ground squirrels, fireweed is a species which occurs in disturbed areas (Nelson 1969). The positive relationship between the two is probably due to the response of both to the disturbance, rather than to each other. Forb leaves have been reported to be an important item in the golden-mantled ground squirrel diet (McKeever 1964). Therefore, the relationship with forbs is probably a response to food abundance. Golden-mantled ground squirrels were trapped most frequently near slash, which provides escape cover. This explains the relationship between these squirrels and the frequency of slash. Slash increases the recreational value to be obtained from golden-mantled ground squirrels since, like chipmunks, they too prefer to perch on and run along the tops of logs.

Deer mice (Peromyscus maniculatus)

Deer mice were more abundant in burns and clearcuts than in forested control plots (Table 5). These results are consistent with results reported elsewhere (Gashwiler 1970; Tevis 1956a; Taylor 1969; Roppe 1974; Krefting and Ahlgren 1974).

Regression analysis indicates a negative relationship exists between deer mice (Table 5) and the frequency of dwarf huckelberry and the frequency of shrubs (Table 7). Since deer mice are an opportunistic species which occurs frequently in disturbed areas, negative relationships with dwarf huckelberry and shrubs are readily explained. The frequency of shrubs is closely related to the frequency of dwarf huckelberry (Table

7). Both of the control plots have the highest frequencies of dwarf huckelberry in their respective areas. Deer mice are less abundant in these plots due to their forested nature. Therefore, negative relationships are to be expected.

Regression analysis also indicates deer mice abundance to be positively related to the frequency of C. brevipes, the frequency of forbs, the frequency of grasses, and the number of plant species present (Table 7). There are more forbs and more plant species in the plots where dwarf huckelberry is less abundant. These happen to be disturbed areas where deer mice are more abundant. It is probable deer mice are responding to the forbs and the number of plant species as an adequate and varied food supply. The relationships with C. brevipes and grasses are not so evident. These plants may provide food or cover, or a combination of both. Grasses combined with forbs would provide a varied food supply. Some believe large herbivores (i.e., mammals) need a varied food supply to avoid the effects of toxic secondary compounds produced by plants (Freeland and Janzen 1974).

Heather voles (Phenacomys intermedius)

The heather vole was abundant only in the Sierra Madre burned and clearcut plots (Table 5). This species has been reported to be more abundant in spruce-fir forests than in lodgepole pine forests (Brown 1967). The Sierra Madre study area was a lodgepole pine, spruce-fir forest before logging and burning, while the Snowy Range area was almost pure lodgepole pine. Therefore, it is possible that the community present before the perturbation has some effect on whether or not heather voles will be present afterwards. Heather voles in the Medicine Bow Mountains have also

been reported to be more abundant within 180-m of water than they are at distances over 180-m (Brown 1967). In this investigation, most of the traps were within 180-m of water, except for the Sierra Madre control plot, which was over 200-m from water. Traps set in burned plots were closer to water than those in clearcut plots, the traps in the Sierra Madre burned and clearcut plots were somewhat closer than those in the Snowy Range burned and clearcut plots. In addition, the Sierra Madre study area is naturally more moist than the Snowy Range study area (Table 1). This could explain the greater abundance of heather voles observed in the Sierra Madre study area.

Shrews (*Sorex* spp.)

Shrews were most abundant in the Snowy Range control plot (Table 5). These animals were caught in a moist area of the study plot, within 25-m of a wet park. This is to be expected, since this genus prefers moist conditions (Burt and Grossenheider 1964). Some shrews were also trapped on the Sierra Madre study plots. These plots were not as moist as the portion of the Snowy Range control where shrews were trapped. A different species may have been present in the Sierra Madre study plots. The shrews captured were either *S. vagrans* or *S. cineureus*. It was impossible to differentiate between the two under field conditions. *S. vagrans* requires more moisture in its habitat than does *S. cineureus* (Burt and Grossenheider 1964). Therefore, it is possible the shrews in the Snowy Range control were *S. vagrans* while those in the Sierra Madre study plots were *S. cineureus*.

Total Small Mammals

The total number of small mammals present was greater in the burned and clearcut plots than in the control plots (Table 5). In addition, the total number of small mammals was greater in both clearcuts than in both burns during both years. If there was no relationship between burns and clearcuts, the chance of clearcuts having more small mammals in either area in either year would be 0.5. The chance of there being more small mammals in both clearcuts in both years would be $(0.5)^4$ or 6.25%. It appears clearcuts have more total small mammals than do burns. Regression analysis indicates the total number of small mammals (Table 7) is negatively related to the total amount of vegetation present and positively related to the frequency of fireweed and the frequency of slash (Table 7). These relationships are probably due to golden-mantled ground squirrels and least chipmunks being the majority of small mammals present. Therefore, the total number of small mammals present would be reflected in the relationships of golden-mantled ground squirrels and least chipmunks.

Small mammals, especially the more visible, diurnal ones, such as ground squirrels and chipmunks are considered aesthetically pleasing by many people, many of whom vacation or weekend in mountainous areas where clearcutting takes place. Therefore, it would be advantageous to treat clearcuts in a manner such that small mammals would be abundant by leaving some slash in place.

Pacific northwest investigators have been concerned with the effects of small mammals on reforestation after logging (Gashwiler 1970; Tevis 1956a; Radvanyi 1966). In this investigation the plot with the most reforestation, the Snowy Range clearcut (Table 8) also had the most

Table 8. Density of trees less than 2cm dbh occurring in the study plots. + indicates presence in trace amounts.

Species	Snowy Range			Sierra Madre		
	Burn	Clearcut	Control	Burn	Clearcut	Control
Pinus contorta	2041	6562	100	0	+	900
Picea engelmanii	0	625	100	0	0	4100
Abies lasiocarpa	0	417	400	0	+	400

small mammals, all of which are known seed eaters (Smith and Aldous 1947). However, in order to really determine the effects of small mammals on reforestation the areas should be studied immediately after logging or burning, since this is when most seed predation can be expected to occur. In addition, exclosure experiments and food habit studies of the small mammals on the areas being studied should be performed to determine whether or not small mammals are affecting reforestation.

Big Game

Time-lapse Photography

Time-lapse camera data indicated twice as many deer in the Snowy Range clearcut as in the Snowy Range burn (Table 9). The Sierra Madre clearcut had three times as many deer as the burn. No elk were observed in either burn, but 17 elk were observed in the Snowy Range clearcut and two in the Sierra Madre clearcut (Table 9). These figures represent total numbers of animals in each frame with deer and elk present. The same animal may be present in more than one frame.

The number of days deer and elk were observed is an indication of frequency of use of a plot. There was very little difference in frequency of use by deer in the Snowy Range, while in the Sierra Madres the burn was used six times as often as the clearcut. In both areas elk were observed in clearcuts on more days than in burns (Table 9). Values for frames/100 days of camera use/ha give a frequency of use value which considers the number of days of camera use in each area and size of viewing area. These data are similar to the number of deer and elk observed (Table 9). The differences in number of camera use days are

Table 9. Results of time-lapse photography. Number of deer and elk seen is a sum of all the deer and elk seen in each frame with deer and/or elk present.

	Snowy Range		Sierra Madre	
	Burn	Clearcut	Burn	Clearcut
Area viewed (ha)	0.12	0.05	0.05	0.15
Camera use days	138	134	149	128
Days with deer present	4	5	6	1
Number of deer	6	13	6	19[a]
Days with elk present	0	4	0	2
Number of elk	0	17	0	2
Frames with deer/100 days of camera use/ha	25	160	80	100
Frames with elk/100 days of camera use/ha	0	160	0	13

[a]This figure is due to one individual that bedded down in front of the camera for 105 minutes.

Table 10. Number of deer and elk fecal groups per ha. occurring on the study plots. Standard errors are in parentheses.

Year	Species	Burn	Clearcut	Forest	Park	Burn	Clearcut	Forest	Park
1973									
	Deer	238(±50)	142(±32)	180(±25)	--	328(±58)	198(±48)	88(±20)	--
	Elk	402(±68)	60(±22)	138(±18)	--	212(±28)	125(±32)	110(±20)	--
	Total	640(±98)	202(±48)	318(±35)	--	540(±70)	322(±68)	198(±32)	--
1974									
	Deer	185(±30)	20(±12)	--	20(± 8)	140(±32)	108(±22)	--	172(±30)
	Elk	185(±32)	15(± 8)	--	80(±20)	185(±25)	50(±12)	--	360(±45)
	Total	370(±48)	35(±15)	--	100(±22)	225(±50)	158(±28)	--	532(±60)

due to several factors: the cameras were in the field for different lengths of time, some days were eliminated due to condensation on the camera lens, and one camera was stolen.

Remote camera data indicate both deer and elk prefer clearcuts to burns. This is in contradiction to the fecal-group count data, which indicate just the opposite (Table 10). This discrepancy can be explained in several ways. Visibility is much better in the clearcut plots due to large amounts of standing dead timber in the burns (Table 11, Fig. 3). All deer use in the Sierra Madre clearcut was due to one individual which bedded in front of the camera for 105 minutes on 6 August 1974. In addition, sample sizes from the camera data are small. Cameras may be valuable tools in areas with high use and high visibility, such as winter range, fawning and calving grounds, and water holes, but in studies such as this, with differences in visibility and animals dispersed over a wide area of summer range, cameras are not as productive. For these reasons, in this study, the fecal-group count data were considered more reliable and more informative.

Fecal-group Counts

The use of fecal-group count data assumes deer and elk use all plots for the same purpose (Neff 1968). In this study, it was assumed that openings are used mainly for feeding with some resting, while forested plots are used mainly for resting and a small amount of feeding. Deer were observed feeding and resting in both burns and clearcuts. They were not seen in the forested plots, but they were jumped off beds in the forested plots. Elk were seen once each in the Sierra Madre burn, clearcut, and park, feeding each time.

Table 11. Density of standing dead timber in burned and clearcut plots as determined from aerial photographs (scale 1:5280) taken in 1973.

Area Plot	Trees/ha
Snowy Range	
Burn	722
Clearcut	0
Sierra Madre	
Burn	633[a]
Clearcut	64

[a]Blown-down dead timber composes 17% of this plot. If this portion of the plot is left out of the density calculations, the density of standing dead timber becomes 1060 trees/ha.

A

C

B

D

Fecal-group data indicate both mule deer and elk use burned plots more than clearcut plots. No clear relationships between disturbed areas and forested areas or parks were indicated (Table 10). Regression analysis indicates deer use and elk use is related to the frequency of forbs, the frequency of vegetation, and the number of plant species present (Table 7). Several other investigators have shown mule deer prefer forbs during the summer (Compton 1974; Strickland 1975; Julander et al. 1961; Martinka 1968; Mackie 1970). On the western slope of Wyoming's Sierra Madre, elk prefer grasses during the summer (Compton 1974). However, elk in Montana's Missouri River breaks and Littlebelt Mountains prefer forbs during the summer (Mackie 1970; Kirsch 1962).

The most abundant species of forbs in the study areas, fireweed, heartleaf arnica (Arnica cordifolia), and silvery lupine (Lupinus argenteus), have been reported to be used moderately by mule deer during the summer. The major grasslike species, Carex brevipes, is reported to be little used, and the major shrub, dwarf huckleberry, is moderately used (Kufeld et al. 1973). Fireweed and heartleaf arnica are reported to be valuable to elk during the summer, while silvery lupine is least valuable. Carex spp. is reported to be valuable to elk, but C. brevipes is not mentioned, nor is dwarf huckelberry (Kufeld 1973). These results indicate availability of preferred food items is at least partially responsible for the use of an area by mule deer and elk.

Forage Nutrient Content

Better quality forage in heavy use areas could also explain preferential use by mule deer and elk. Although analysis of forage nutrient

content shows few significant differences, trends are shown by forage phosphorus, sodium, and protein content (Table 12).

Phosphorus

Phosphorus requirements for elk and mule deer are not known, but work done with white-tailed deer fawns can be used as a guideline (French et al. 1956; Ullrey et al. 1975). Studies in Michigan indicate 0.28% phosphorus is adequate for growth when 0.46% calcium is present (Ullrey et al. 1975). Other studies show good growth with 0.29% calcium and 0.26% phosphorus (Ullrey et al. 1973). These were the lowest values tested; lower values, such as the ones found in this study (Fig. 4) may also be adequate.

The amount of calcium present is important, since Ca:P ratios less than 1:1 are thought to be detrimental (Ullrey et al. 1973). In this investigation the plots which had the heaviest use in each area, had Ca:P ratios less than 1:1 (Fig. 4). However, since deer select forage of higher nutritional value than found by clipping forage (Bissel 1959), it is possible the animals using the forage are actually consuming a Ca:P ratio greater than 1:1.

The phosphorus content of the forage in most of the study plots was less than the 0.28% thought to be adequate, but it is higher than phosphorus content of forage on mule deer ranges in Arizona and New Mexico (Fig. 4). On both of these ranges, calcium content was much higher than on any of the study plots used in this investigation (Urness et al. 1975; Boekker et al. 1972). It appears phosphorus content of forage in the study plots is adequate, and mule deer and elk may be selecting forage of higher phosphorus content than shown by the analysis.

Table 12. Nutrient content of forage in the study plots. Forage was collected five times throughout the summer. Values are averages for the whole summer. Data were treated statistically by use of Wilcoxon's signed rank test (Sokal and Rohlf 1969).

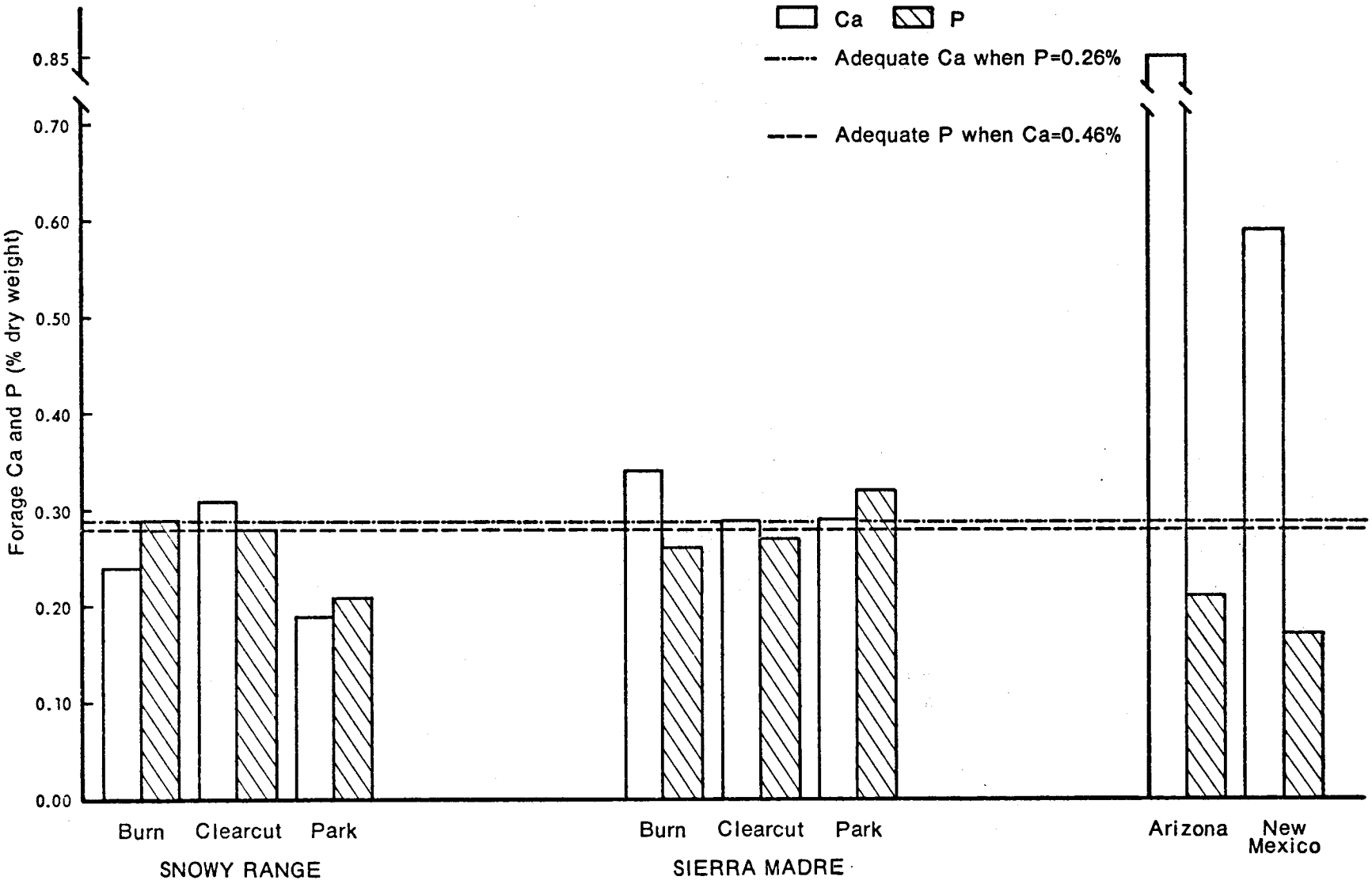
Nutrient (% dry wt)	Snowy Range			Sierra Madre		
	Burn	Clearcut	Park	Burn	Clearcut	Park
Protein	12.12	12.22	11.42	11.70[a,b]	10.82[c]	14.78
Fat	2.5	3.1	2.9	2.9	3.2[c]	2.8
Crude Fiber	24.96[b]	19.72	21.18	21.54	16.94[c]	21.68
Sodium	0.016	0.014	0.016	0.014	0.014[c]	0.020
Potassium	1.73	1.64	1.28	1.83	1.70	1.77
Calcium	0.24	0.31[c]	0.19	0.34	0.29	0.29
Phosphorus	0.29[b]	0.28[c]	0.21	0.26	0.27	0.32
Energy (Kcal/gm dry wt)	4.49	4.56	4.62	4.49	4.57	4.53

[a]Significant difference between burned and clearcut plots in an area (P = .05)

[b]Significant difference between burned and park plots in an area (P = .05)

[c]Significant difference between clearcut and park plots in an area (P = .05)

Figure 4. Comparison of forage calcium and phosphorus percentages from the study plots. Values determined to be adequate for weaned white-tailed deer fawns (Ullrey et al. 1973, 1975), and values from mule deer summer ranges in New Mexico (Boekker et al. 1972) and Arizona (Urness et al. 1973) are presented for comparison. Data for New Mexico are the averaged values from June, July, and August.


Ca
P
Adequate Ca when P=0.26%
Adequate P when Ca=0.46%
Forage Ca and P (% dry weight)
0.85
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
Burn
Clearcut
Park
SNOWY RANGE
Burn
Clearcut
Park
SIERRA MADRE
Arizona
New Mexico

Sodium

Forage sodium content was also higher in the areas of heavy use (Tables 10 and 12). African elephants (Loxodonta africana) select for sodium in their water supply (Wier 1972), and moose on Isle Royale select for sodium content in their summer diet (Botkin et al. 1973). However, the sodium content of the forage collected in all of the plots was below that required by moose and domestic livestock (Botkin et al. 1973). But, it is known ungulates supplement their sodium intake with salt licks (Botkin et al. 1973). The data from this study are insufficient to conclude that elk and deer select forage of higher sodium content, but they do suggest that it is a possibility, deserving further study.

Protein

Much evidence suggests ungulates select forage of high protein content (Bissel 1959; Einarson 1946; Nagy et al. 1969). Although the heaviest use was on the plot with the highest protein content, this was not true in both study areas.

Results of this investigation do not indicate that the mule deer and elk using the study plots were selecting for protein (Tables 10 and 12). However, all of the values recorded for forage protein content were well above the 5-7% value considered necessary for deer survival (Fig. 5) (Einarson 1946; Dietz 1965). Little has been done to determine the amount of protein necessary in the diets of mule deer and elk. However, protein requirements for white-tailed deer can be used as a guideline (French et al. 1956; Murphy and Coates 1966; Ullrey et al. 1967; Smith et al 1975). These studies indicate 13-16% protein to be necessary for good growth (Murphy and Coates 1966), and 20-25% protein to be necessary for

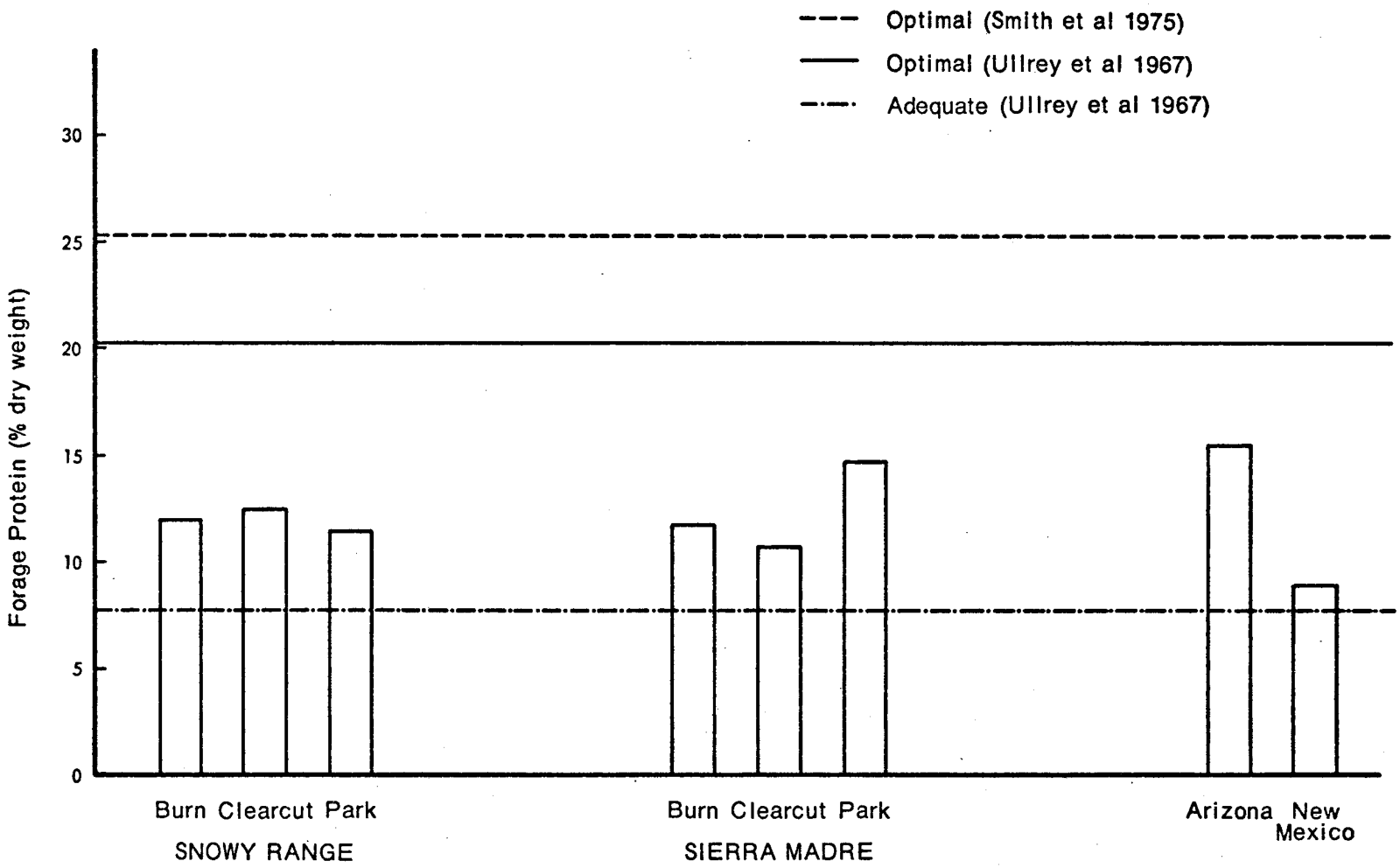
maximum growth (Ullrey et al. 1967; Smith et al. 1975). Some growth has been recorded using a diet of 7-8% protein (Ullrey et al. 1967). Values in this study are well below the values believed necessary for good growth (Fig. 5), but are comparable to values found on other western mule deer ranges (Boekker et al. 1972; Urness et al. 1975).

Most of the phosphorus, calcium and protein requirements summarized here are for white-tailed deer fawns, not for mule deer, elk, or older animals whose requirements may be different. For example, sheep phosphorus requirements are highest in lactating females, not in lambs (National Research Council 1968). It should also be borne in mind that deer select for forage in such a manner that the nutritional levels they are ingesting can be two times as great as the average value determined for an area by forage clipping (Bissel 1959).

One other factor, the amount of cover present, is important to deer and elk use of the study plots. Studies performed in Arizona and Colorado have suggested that standing timber left after fire provides adequate cover (McCulloch 1969; Roppe 1974). In this investigation, deer and elk use was greater in the burned areas with standing dead timber than in the clearcut areas without it (Tables 10 and 11). In the Sierra Madre study area, both the burned and clearcut plots had standing dead timber, but the burned plot with much more standing dead timber had more deer and elk use. Fire opens up the canopy allowing light to enter, stimulating growth of forage plants. The dead trees which are standing, provide good protective cover for the animals.

The data presented here also lead to some speculation. The Sierra Madre park had by far the most deer and elk use in 1974; it also had the

Figure 5. Comparison of forage protein concentration from the study plots. Optimal and adequate values for weaned white-tailed deer fawns, and values from mule deer summer ranges in New Mexico (Boekker et al. 1972) and Arizona (Urness et al. 1975) are presented for comparison. Data for New Mexico are the averaged values from June, July, and August.


Optimal (Smith et al 1975)
Optimal (Ullrey et al 1967)
Adequate (Ullrey et al 1967)
Forage Protein (% dry weight)
30
25
20
15
10
5
0
Burn
Clearcut
Park
SNOWY RANGE
Burn
Clearcut
Park
SIERRA MADRE
Arizona
New Mexico

highest values for forage protein, sodium, and phosphorus content (Tables 10 and 12). It appears reasonable to propose the following hypothesis: heavy feeding use of an area by mule deer and elk results in the accumulation of feces on the area. This results in the fertilization of the area and recycling of nutrients. The potential of that area producing better quality forage is enhanced. As mule deer and elk continue to use the area, the process repeats itself. Although data from this investigation are insufficient to draw such a conclusion, they do suggest it as a possibility deserving investigation.

The Sierra Madre and Snowy Range study areas are both summer range for migrating mule deer and elk herds. Winter range, not summer range, is limiting for deer and elk herds in these study areas (Compton 1974; Strickland 1975). However, summer range is important in determining the condition of the animals as they enter winter (Nordan et al. 1968). This affects herd productivity and survival (Julander et al. 1961). In order to manage forests without altering summer range conditions, it is necessary to determine what types of habitats are used and why they are used. With this information it will be possible to manage the habitats to the benefit of mule deer and elk.

Deer and elk utilize forest openings created by either fire or clearcutting. However, results of this investigation indicate burned areas are preferred to clearcut areas (Table 10), and food availability is an important criterion for determining deer and elk use of an area. Another important factor is cover. In the burned plots, cover is supplied by standing dead timber. The importance of this factor is accentuated by results from the Sierra Madre study area. Burned and

clearcut plots in this area were very similar in vegetative composition (Table 7). However, the burned plot had more standing dead timber (Table 11) and more deer and elk use. Other investigators have indicated that standing dead timber might be important (McCulloch 1969; Roppe 1974), but they didn't have any comparative data. This investigation has comparative data, and stresses the point much more strongly.

These results indicate clearcutting that would benefit deer and elk should be done in a manner that will more closely resemble a burn. Unmerchantable timber should be left standing. If mistletoe or insect infestations are a problem, the trees may be poisoned or girdled. Post logging treatment should be of a type that will be suitable for abundant growth of forb species as well as tree reproduction. Unfortunately, few studies have concentrated on forb species invading an area after logging, and none have compared the effects of different slash disposal treatments on forb production in the central Rocky Mountains.

Avifauna

Burned areas usually had more bird species and greater densities than clearcut areas. Forested controls had fewer species than clearcut plots, but the differences in densities showed no observable trend (Table 13). Hairy Woodpeckers (*Dendrocopus villosus*), Mountain Bluebirds (*Siala currucoides*), Gray-headed Juncos (*Junco caniceps*), Fox Sparrows (*Passerella iliaca*), and American Robins (*Turdus migratorius*) were most abundant in burned plots. No species were consistently most abundant in either clearcut or forested plots.

The presence of more individuals and more species in burned areas

Table 13. Birds/100 ha occurring in the study plots in 1973 and 1974. Results for 1973 are on the left of the slash and 1974 on the right. The guild into which each species was placed is also presented. A + indicates presence in the plot, but not in the census transect.

Species	Guild	Snowy Range			Sierra Madre		
		Burn	Clearcut	Control	Burn	Clearcut	Control
Blue grouse (Dendragapus obscurus)	1232				0/+		+/+
Pine grosbeak (Perisoreus canadensis)	1233				0/+	0/6	
Cassin's finch (Carpodacus cassinii)	1234				0/62	10/38	
Pine siskin (Spinus pinus)	1244				0/62	29/50	
Hairy woodpecker (Dendrocopus villosus)	2111	29/+			40/12	0/6	0/20
Black-backed-3-toed woodpecker (Plicoides arcticus)	2111			0/13			
Mountain bluebird (Siala currucoides)	2231	+/62	0/12		0/150	0/75	+/0
Common flicker (Colaptes auratus)	2331	43/6	0/+				
Golden-crowned kinglet (Regulus satrapa)	2344						0/+
Ruby-crowned kinglet (Regulus calendula)	2344				+/0		+/0

Table 13. (Continued).

Species	Guild	Snowy Range			Sierra Madre		
		Burn	Clearcut	Control	Burn	Clearcut	Control
Western tanager (Piranga ludoviciana)	2444				+/12		+/+
Yellow-rumped warbler (Dendroica coronata)	2444	0/6			0/50	0/19	0/20
Western wood peewee (Contopus sordidulus)	2454	0/6			0/12		
Common nighthawk (Chordeiles minor)	2552	14/25	0/6				
Tree swallow (Iridoprocne bicolor)	2554					0/6	0/10
Olive-sided flycatcher (Nutallornis borealis)	2554	0/6	0/+			0/6	
White-crowned sparrow (Zenotrichia leucophrys)	3232	0/+				0/+	
Gray-headed junco (Junco caniceps)	3232	171/69	57/0	40/13	800/175	257/75	80/80
Hermit thrush (Catharus guttata)	3232				40/0	40/0	0/10
Townsend's solitiare (Myadestes townsendi)	3232				0/12	+/12	0/10
Mourning dove (Zenaida macroura)	3232				0/+	0/12	
Fox sparrow (Passerella iliaca)	3233	0/6			0/75	0/19	

Table 13. (Continued).

Species	Guild	Snowy Range			Sierra Madre		
		Burn	Clearcut	Control	Burn	Clearcut	Control
Chipping sparrow (*Spizella parrerina*)	3234	0/12			60/0	25/0	0/10
American robin (*Turdus migratorius*)	3234	14/19	57/6	120/13	100/238	+/19	+/70
Gray jay (*Perisoreus canadensis*)	3244		+/25	0/27	0/12	0/6	0/10
Clark's nutcracker (*Nucifraga culumbiana*)	3444				+/0	+/0	+/0
Unidentified hummingbird		14/6			20/0	0/6	
Total Density		285/223	114/49	160/66	1070/872	324/355	120/240
Total Number of Species Present		5/10	3/6	2/4	9/15	8/15	7/12
Total Number of Guilds Present		5/10	3/6	2/4	6/12	5/11	7/8

than in the control plots is consistent with other studies in central Rocky Mountain lodgepole pine forests (Taylor 1973; Roppe 1974), but in disagreement with observations made in the Sierra Nevada Mountains of California (Bock and Lynch 1970), where there was little difference in species composition and total density between burned and unburned plots. However, there were differences in species abundance. As in this investigation, Dark-eyed Juncos, American Robins, and Fox Sparrows were more abundant on burned plots than on unburned plots (Bock and Lynch 1970).

The number of bird species was negatively correlated with the frequency of dwarf huckelberry and the frequency of all shrubs (Table 7). The number of bird species was positively related to the frequency of C. brevipes, the frequency of all forbs, the frequency of all grasses, and the number of plant species present. These vegetative attributes show the same relationship with the number of plant species as they show with the number of bird species (Table 14). Therefore, they are all manifestations of the relationship between the number of bird species and the number of plant species. This relationship between the number of plant species and the number of bird species is in contradiction to other results which show no relationship between bird species diversity and plant species diversity (MacArthur and MacArthur 1961).

The number of guilds present in an area is an index to the different kinds of birds present, or, in a very broad sense, the various niches occupied by birds. Burned plots had more guilds than either clearcut or forested plots, and clearcut plots usually had more than forested plots (Table 13).

The greater number of guilds present in burned areas indicates

Table 14. Correlation, as indicated by the correlation coefficient (r), between the number of plant species present in a plot and other vegetative attributes of the plots. An $|r| = 0.58$ is significantly different from 0 ($P = 0.05$) (Rohlf and Sokal 1969).

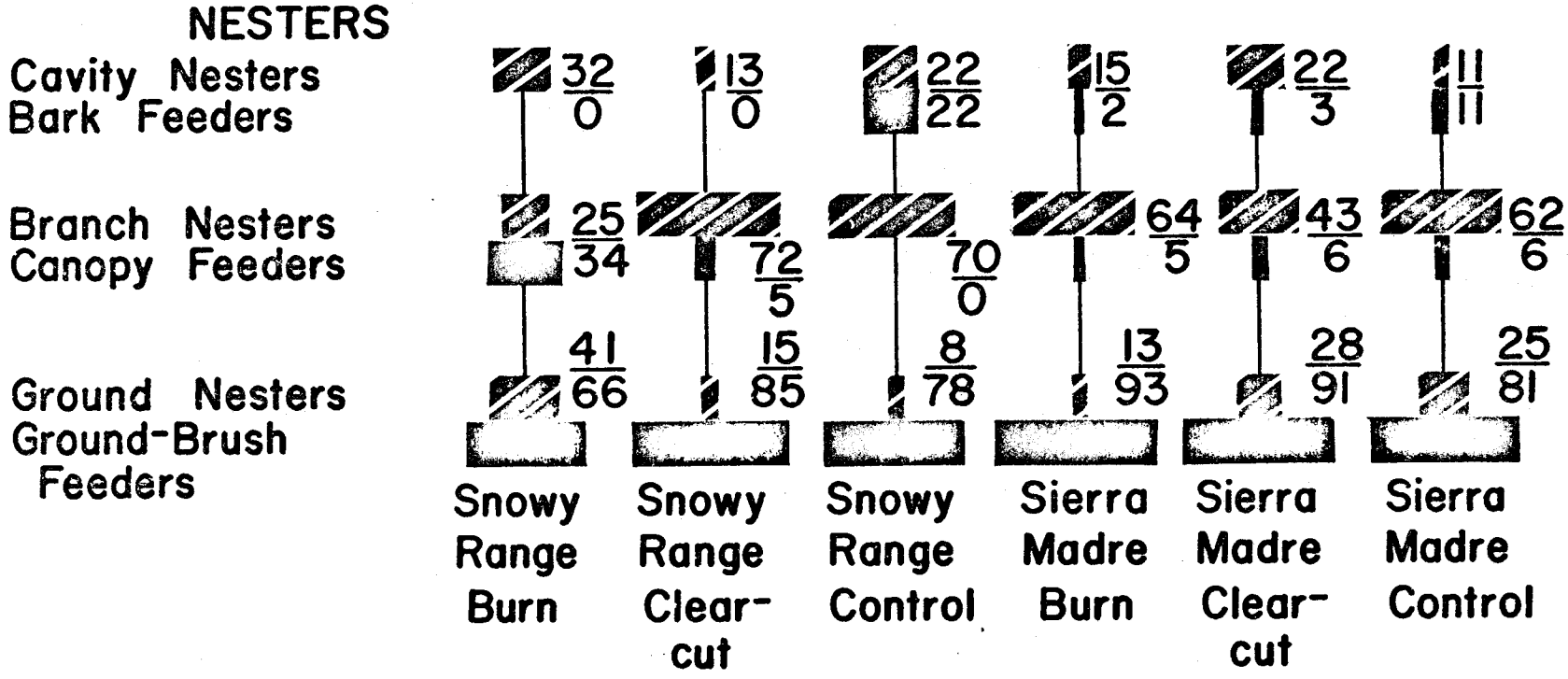
Attribute	r	r^2
Total frequency of vegetation	0.06	0.004
Frequency of *Vaccinium scoparium*	-0.85	0.72
Frequency of *Carex brevipes*	0.63	0.40
Frequency of forbs	0.80	0.64
Frequency of grasses	0.85	0.72
Frequency of shrubs	-0.84	0.71

more niches are available. It is well established that greater habitat heterogeneity leads to a greater number of bird species in an area (Karr 1968; MacArthur 1964; Recher 1969; Willson 1974). The standing dead timber present in the burned plots (Table 11) adds a component to the habitat that is not present in the Snowy Range clearcut. The Sierra Madre clearcut has some standing dead timber, and has the same number of guilds and species as the burned plots. The Snowy Range control and clearcut had the fewest species, total birds, and guilds present; these areas also had the least heterogeneity. The clearcut had very little standing timber and no snags (Table 7). Its herbaceous vegetation was mostly one species, dwarf huckelberry (Table 7). The control had much mature lodgepole pine present and very few spruce and fir (Table 15). The understory was almost exclusively dwarf huckelberry. Since most of the birds present in all the plots were ground-brush feeders (Fig. 6), a wide variety of food types is desirable to support a wide variety of bird species. Neither the Snowy Range control or clearcut meets this requirement. The Sierra Madre control consisted of a lodgepole pine overstory and an understory of spruce and fir (Tables 15 and 8). In addition, it had a wider variety of plant species than the Snowy Range control (Table 7). As a result of these factors the Sierra Madre control was able to support more bird species and guilds than its counterpart in the Snowy Range.

Larger birds have lower metabolic rates per unit weight and, therefore, require less food per unit of body weight than smaller birds. Measurement of consuming biomass compensates for differences in body size giving better estimates of energy flow than either standing crop biomass or density figures (Salt 1957). Consuming biomass indicates

Table 15. Density of living trees (trees/ha) greater than 2 cm dbh occurring in the study plots.

	Snowy Range			Sierra Madre		
	Burn	Clearcut	Control	Burn	Clearcut	Control
Pinus contorta	0	0	1480	0	0	748
Picen engelmannii	0	0	80	0	0	196
Abies lasiocarpa	0	1	40	0	0	1155


NESTERS
Cavity Nesters
Bark Feeders
Branch Nesters
Canopy Feeders
Ground Nesters
Ground-Brush
Feeders
32/0
13/0
22/22
15/2
22/3
11/11
25/34
72/5
70/0
64/5
43/6
62/6
41/66
15/85
8/78
13/93
28/91
25/81
Snowy Range Burn
Snowy Range Clear-cut
Snowy Range Control
Sierra Madre Burn
Sierra Madre Clear-cut
Sierra Madre Control

the same trends as does density (Table 16). In all the study plots except the Snowy Range clearcut, the largest portion of total consuming biomass is composed of omnivorous species, which are primarily insectivorous in the summer. In the Snowy Range clearcut the largest portion of the consuming biomass is composed of insectivorous species (Fig. 7). Therefore, the majority of the birds on the study plots during the summer months are secondary consumers, indicating insects are abundant.

Analysis of the amount of consuming biomass in the various guilds present in the study plots indicates the majority of the birds in each plot are ground feeders, and the largest proportion in each study plot, except the Snowy Range burn, is branch nesters (Fig. 6). In the Snowy Range burn the largest portion is ground nesters. This is due to the presence of the Common Nighthawks (Chordeiles minor).

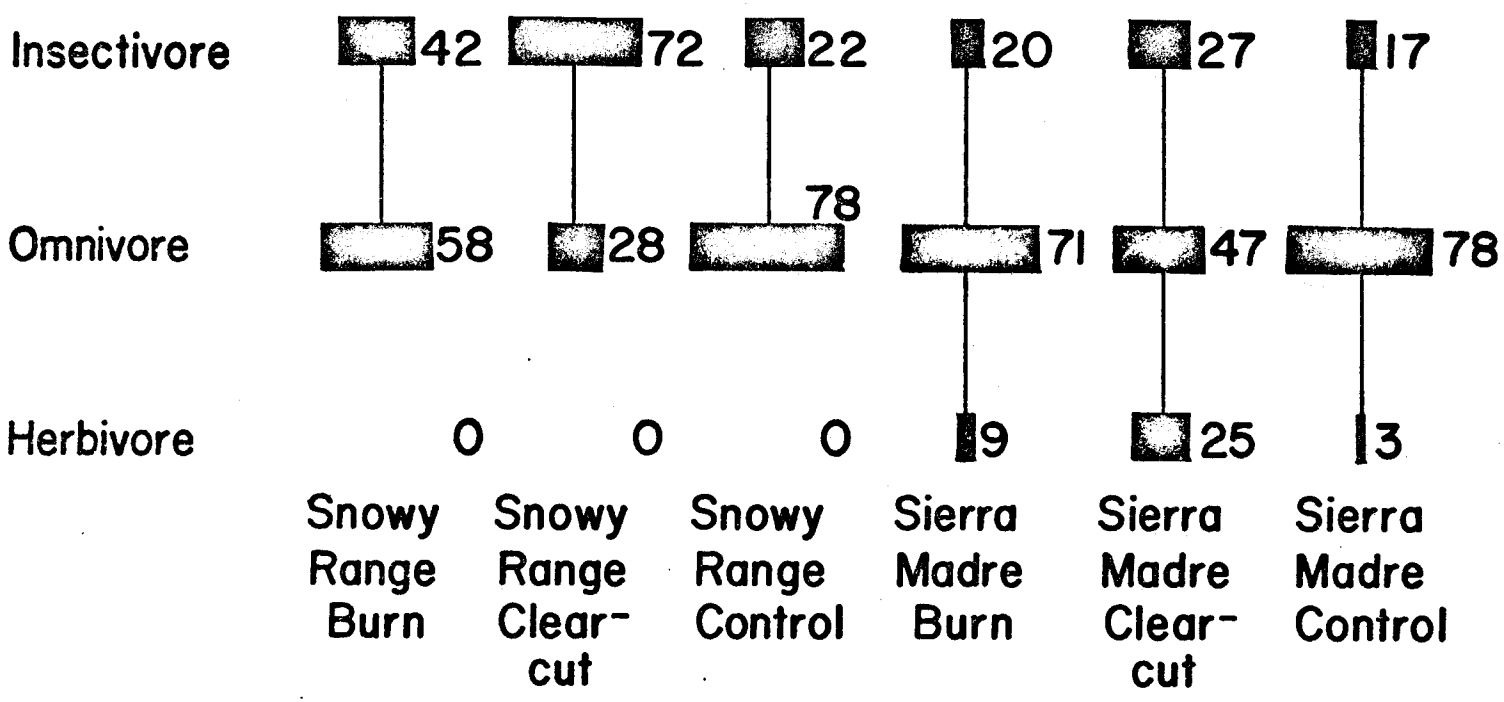
Most birds present in all the study plots were insectivorous ground feeders and branch nesters, indicating that energy probably flows through the same pathways in all of the study plots. The percentages of consuming biomass present in each of these categories were about the same, but the actual amounts in the study plots varied (Fig. 6 and Table 16). The Sierra Madre clearcut and burn are a good example of this. The areas are very similar in vegetative composition (Table 7). This would indicate food to be about the same in both areas, but the number of birds supported differs greatly. If food isn't limiting the bird populations in the Sierra Madre clearcut, then something else must be. One very noticeable difference is the amount of standing timber available for nesting habitat in the two plots (Table 11). It appears likely that this could be the limiting factor for insectivorous species. Others have

Table 16. Mean weight (gms) and consuming biomass (gms) of birds occurring in the study plots in 1974.

Species	Mean wt.	Snowy Range			Sierra Madre		
		Burn	Clearcut	Control	Burn	Clearcut	Control
Pine grosbeak	53					98	
Cassin's Finch	28				638	638	102
Pine siskin	12				358	286	
Hairy woodpecker	73				244	122	390
Black-backed-3-toed woodpecker	75			269			
Mountain bluebird	27	621	124		1491	746	
Common flicker	151	206					
Western tanager	30				132		
Yellow-rumped warbler	14	38			302	113	121
Western wood peewee	15	40			79		
Common nighthawk	81	541	135				
Tree swallow	21					51	81
Olive sided flycatcher	33	70				70	
Gray-headed junco	18	514		100	1307	560	598
Hermit thrush	26						97
Townsend's solitaire	55				201	201	161
Mourning dove	135					377	
Fox Sparrow	30	68			822	206	

Table 16. (Continued)

Species	Mean wt.	Snowy Range			Sierra Madre		
		Burn	Clearcut	Control	Burn	Clearcut	Control
Chipping Sparrow	72						
Robin	88	431	144	306	5455	431	1608
Gray Jay	75		512	546	256	128	205
Total consuming biomass		2602	915	1221	11285	4027	3422


Insectivore
Omnivore
Herbivore
42
72
22
20
27
17
58
28
78
71
47
78
0
0
0
9
25
3
Snowy Range Burn
Snowy Range Clear-cut
Snowy Range Control
Sierra Madre Burn
Sierra Madre Clear-cut
Sierra Madre Control

indicated the importance of leaving some snags standing, after logging, for cavity nesters (Balda 1975; Conner 1974; Wiens 1975). The results of this investigation indicate standing snags are also important for other species as well.

The Snowy Range study area had no herbivorous species present, but the Sierra Madre study area did (Fig. 7). The Sierra Madre study area had more seed-producing grasses and forbs than did the Snowy Range study area (Table 7). This suggests food to be a limiting factor for herbivorous birds in the study areas.

Areas with a wider variety of plants present are able to support a wider variety of insects (Pimental 1961). This is important since most of the birds present are secondary consumers (Fig. 7). Insectivorous birds are important in controlling forest insect populations (Thomas et al. 1975). A wider variety of birds will be able to control a wider variety of insects; therefore, it is beneficial to have a wide variety of birds present. Most of the birds present feed at or near ground level, but nest above the ground (Fig. 6). Standing dead timber provides nesting sites for many of these birds; therefore, it would be beneficial to leave some timber standing after a logging operation. It would also be beneficial to have a wide variety of plant species present. Burned plots had more species than clearcut plots. Although the Sierra Madre clearcut appears to be an exception, it was entirely burned in the same fire that burned the Sierra Madre burned plot.

If the above indications are true, it leads to the question of whether there are more insects present in areas with less standing timber, and whether these areas would be more prone to large fluctuations in their

insect populations. If more insects are present and their populations are more likely to undergo large increases, what effect does this have on energy flow through the system? The results of this investigation give indications allowing these questions to be asked, but do not give answers to the questions.

Some investigators have indicated that seed eating birds, such as Blue Grouse, Gray Jays (Perisoreus canadensis), American Robins, Juncos, and Pine Skskins (Spinus pinus), may have a detrimental influence on the number of trees germinating after clearcutting (Smith and Aldous 1947; Gashwiler and Ward 1966, 1968). General observations in this study show that there are more birds in the areas with fewer young trees (Tables 5 and 13). To adequately test this hypothesis, exclosure experiments and food habit studies would have to be performed starting at the time logging ceased.

Burned plots had more plant species present than did clearcut plots. The data are not sufficient to conclude that fire favors plant species richness more than logging does, but they do indicate that this might be the case. Site factors and post-logging treatment might also influence the number and types of plants invading an area after logging. Since the number of plant species present influences both big game and bird use of these areas, the factors affecting their invasion after logging should be thoroughly investigated.

Recently other investigators have argued that forests should be managed for groups of birds that naturally occur together (Balda 1975; Wiens 1975). These species having evolved to live together make more efficient use of available resources. Since fire is a natural

perturbation and clearcutting is not, it would seem advisable to manage for those species which naturally occur after fire. This could be accomplished by leaving dead snags and some unmerchantable timber standing, and by using post-logging treatment that will maximize the number of plant species invading the logged area. Results of this study suggest this would increase the number of bird species in an area and possibly control insect populations.

CONCLUSIONS AND RECOMMENDATIONS

In the State of Wyoming, the logging industry had a sales volume of $31,694,199 in 1973 (Department of Economic Planning and Development 1974), while deer and elk hunters spent approximately $25,000,000 during the same year. This figure is derived with the following formula:

$$A + (B-C)K = E$$

Where: A = Total cost of deer and elk licenses sold in 1973.

B = Total hunter expenditures in 1970 (Doll and Phillips 1972).

C = Total cost of deer and elk licenses sold in 1970.

K = 1.116, an inflation multiplier (Lerner 1973).

E = Total deer and elk hunter expenditures.

In addition, bird watchers spent an estimated $500,000,000 in the United States during 1974 (Payne and DeGraaf 1975). It is not known how much of this was spent in Wyoming. It is obvious, however, that large amounts are spent on wildlife related activities in the State of Wyoming, almost as much as the logging industry's total sales volume. Therefore, in addition to ecological reasons, there are strong economic incentives for managing Wyoming's forests in a manner beneficial to wildlife.

Data from this study are insufficient to draw any conclusions regarding vegetation in the study plots, but they do suggest:

1. Neither forest fire nor clearcutting leave much standing live timber (Table 15) but reforestation takes place more rapidly after clearcutting (Table 8).

2. Burned areas have more forbs available for forage than do clearcut areas.

Results of this investigation allow the following conclusions with regard to forest fire and clearcutting in the central Rocky Mountains:

1. Least chipmuncks and golden-mantled ground squirrels are more abundant in clearcut areas than in burned areas (Table 6).

2. Deer mice are more abundant in burned and clearcut areas than in forested areas (Table 6).

3. Red-backed voles are more abundant in forested areas than in burned or clearcut areas (Table 6).

4. The total number of small mammals in clearcut areas is greater than in burned or forested areas (Table 6).

5. Mule deer and elk prefer burned areas with standing dead timber over clearcut areas from the fifth to the tenth year after the perturbation (Table 12).

6. Birds also prefer burned areas with standing dead timber over clearcut areas from the fifth to the tenth year after the perturbation (Table 13).

7. For burned and clearcut areas over five years of age, there is no significant difference in forage nutrient content.

The abundance of least chipmunks, golden-mantled ground squirrels, and total small mammals is at least partially related to the amount of slash present. It is recommended some slash be left after logging to provide small mammal habitat.

Preferences shown by mule deer, elk, and birds are a result of at least two factors: the presence of standing dead timber in burned areas, and the presence of a wide variety of forage in burned areas. It is advantageous, therefore, to clearcut in a manner that will closely simulate wildfire. Some unmerchantable timber and dead snags should be left standing after the logging operation is completed. This will provide mule deer and elk cover and bird nesting sites.

The amount of forage invading an area after logging should be maximized. The results do not indicate how this can be done, nor does the literature. It is, however, reasonable to assume that post-logging treatment affects forage production. It is recommended an investigation be made concerning the effects of post-logging treatment on forage production.

This investigation was a short term one, investigating only early successional stages. The conclusions drawn here may not be valid for later successional stages. It is recommended long term studies be initiated to:

1. Determine the effects of post-logging treatment on forage production, and
2. determine how fire and clearcutting compare over a long period

of time.

The best way to do this is to clearcut several areas in the same watershed, and give them different post-logging treatments. At the same time several areas in the watershed could be burned, preferably in late summer or autumn, since this is the time of year when fires most often occur naturally.

Several other interesting studies are also suggested by the results. These would determine:

1. The effects of small mammal and bird populations on reforestation in the central Rocky Mountains,

2. The nutritional requirements of mule deer and elk,

3. Whether the absence of birds in areas without suitable nesting sites leads to higher levels of insect abundance, and

4. Whether mule deer and elk effectively fertilize areas of high feeding use with their feces.

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Table 1. Frequency of occurrence and percent cover of plant species occurring in the study plots in 1973. Frequency is on the left of the slash and percent cover on the right. A + on the right of the slash indicates less than one percent cover. A single + indicates presence in the plot.

Species	Snowy Range			Sierra Madre		
	Burn	Clearcut	Control	Burn	Clearcut	Control
Abies lasiocarpa					1/+	11/2
Achillea millifolia				1/+		1/+
Agropyron smithii		1/+				
Agrostis verioblis	4/+					
Antennaria rosea	21/3					1/+
Arabis sp.	16/+					
Arenaria congesta	10/2					
Arnica cordifolia	3/+	12/1	8/+	47/7	40/5	39/4
Bromus anomales	1/+					
Calamagrostis canadensis	6/2			5/1		
Caltha leptosepala				17/4		
Carex brevipes	33/5	11/2		44/11	47/12	28/3
Chenopodium sp.	1/+					

Table 1. (Continued)

Species	Snowy Range			Sierra Madre		
	Burn	Clearcut	Control	Burn	Clearcut	Control
Circium arvense	1/+				1/+	
Collomia linearis	1/+					
Deschampsia caespitosa		2/+				
Elymus canadensis		2/+				
Epilobium angustifolium	5/+	50/5	6/+	40/6	57/9	8/+
Epilobium latiflorum				1/+	6/+	
Equisetum arvense				1/+		
Erigeron peregrinus				2/+	1/+	
Frigaria ovalis	2/+	5/1		4/+	1/+	
Galium boreale		1/+				
Gayophytum ramosissimum	12/+					
Hieracium albifloris	3/+	4/+	2/+	8/+	2/+	
Hieracium gracile						29/3
Hordeum jubatum					1/+	

Table 1. (Continued)

Species	Snowy Range			Sierra Madre		
	Burn	Clearcut	Control	Burn	Clearcut	Control
Juncus sp.				11/4		
Juniperus communis						2/+
Lupinus argenteus	27/4	3/+				+
Mahonia repens	4/+	1/+	4/+	3/+	1/+	1/+
Oryzopsis exiqua	3/1					
Phleum pratense	2/+					
Picea engelmannii		1/+				
Pinus contorta	5/+	15/2			+	
Poa compressa					1/+	
Poa juncifolia	10/2	3/+				4/+
Pyrola sp.			1/+			
Rosa woodseii		+	1/+	5/+	9/1	1/+
Senecio eremophylis	21/1	1/+		8/+	7/+	
Senecio triangularis				4/+		
Sitannion hystrix	3/+					

Table 1. (Continued)

Species	Snowy Range			Sierra Madre		
	Burn	Clearcut	Control	Burn	Clearcut	Control
Solidago spatulata		2/+	1/+			
Taraxicum officinale	28/2	1/+		3/+	2/+	
Trisetum spicatum	13/+	1/+		1/+	8/+	
Vaccinium scoparium	6/+	76/17	97/37	70/14	41/6	89/27

Table II. Frequency of occurrence and percent cover of plants occurring in the study plots in 1974. Frequency is on the left of the slash and cover on the right. A + on the right of the slash indicates less than one percent cover. A lone + indicates presence in the plot but not in the sample quadrats.

Species	Snowy Range				Sierra Madre			
	Burn	Clearcut	Control	Park	Burn	Clearcut	Control	Park
Abies lasiocarpa						2/+	12/2	
Achillea lanulosa								40/4
Achillea millifolia	5/+			5/+				
Agoseris glauca								5/+
Agropyron smithii	2/+							
Agrostis verioblis	2/+							
Antennaria anaphoides	5/+			8/3				
Antennaria rosea	22/3							12/+
Arabis sp.								12/+
Arenaria congesta	15/1						8/+	22/+
Arnica chasmissonis					8/3			
Arnica cordifolia	5/+	12/1	15/2		65/8	50/6	52/4	30/2
Aster sp.					12/2			

Table II. (Continued)

Species	Snowy Range				Sierra Madre			
	Burn	Clearcut	Control	Park	Burn	Clearcut	Control	Park
Bromus anomales	2/+							
Calamagrostis canadensis	12/+	5/+			2/+			
Caltha leptosepala					+			
Carex brevipes	49/8	13/4	5/+		50/9	50/13	20/3	30/2
Carex sp.				25/4	8/2			2/+
Circium arvense						10/+		
Colomia linearis	2/+							
Deschampsia caespitosa				88/47				
Elymus canadensis						2/+		
Epilobium angustifolium	2/+	52/5	2/+		50/8	68/12	5/+	10/+
Epilobium latiflorum					2/+	8/+		
Erigeron peregrinus					2/+	2/+		
Erigeron simplex								10/2
Erigeron sp.				10/2				2/+
Frasera speciosa	2/+	5/+						2/+

Table II. (Continued)

Species	Snowy Range				Sierra Madre			
	Burn	Clearcut	Control	Park	Burn	Clearcut	Control	Park
Frigaria ovalis		+			+	2/+		
Galium boreale						5/+		
Gayophytum ramosissimum	10/+	2/+						
Hieracium albifloris		2/+					5/+	
Hieracium gracile							8/+	
Juncus sp.					+			
Juniperis communis							2/+	2/+
Lupinus argenteus	18/1	2/+					+	38/5
Mahonia repens	8/+	+	+		2/+	+	5/+	
Pedicularis rasmosa							2/+	
Penstamen sp.				18/4				
Phleum pratense	+			+				
Picea engelmannii		2/+					+	
Pinus contorta	12/1	28/4	2/+			+	+	
Poa nervosa							8/+	

Table II. (Continued)

Species	Snowy Range				Sierra Madre			
	Burn	Clearcut	Control	Park	Burn	Clearcut	Control	Park
Potentilla sp.						2/+		
Rosa woodseii		+				15/1	8/+	2/+
Salix sp.				10/2				
Senecio eremyphylis	18/1			25/2	10/+	5/+		
Senecio spartoides								2/+
Senecio triangularis					2/+			
Sitannion nystrix	16/+							
Solidago spatulata		+						
Spergularia rubra	2/+							
Taraxicum officinale	32/4	2/+	+		+	10/1	+	2/+
Trisetum spicatum	5/+				5/+	10/1		
Vaccinium scoparium	+	77/21	100/35		82/21	55/11	95/26	62/15